REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
		FINAL

4. TITLE AND SUBTITLE
Materials Science and Fabrication of YBCO-SrTi1-xNbzO3-YBCO Device Structures

5. FUNDING NUMBERS
61102F
2305/GS

6. AUTHOR(S)
Dr Hou

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
SUNY/Stony Brook

8. PERFORMING ORGANIZATION REPORT NUMBER
AFOSR-TR- 95 0137

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR/NE
110 Duncan Avenue Suite B115
Bolling AFB DC 20332-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
F49620-92-J-0111

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
SEE FINAL REPORT ABSTRACT

19950324 007

14. SUBJECT TERMS	15. NUMBER OF PAGES
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED

Final Report

Materials Science and Fabrication of YBCO-$SrTi_{1-x}Nb_xO_3$-YBCO Device Structures

Shang Hou, SUNY at Stony Brook/AT&T Bell Laboratories

1 Introduction

As described in our proposal for making YBCO/SrTiNbO/YBCO junctions, the success of this project relies on work in three different thrusts:

- Growth of high quality, ultra-thin high-T_c YBCO films.
- Acquisition of metallically doped $SrTiO_3$ substrates with high structural quality.
- The fabrication and characterization of S-N-S Josephson structure based on YBCO/SrTiNbO heteroepitaxy.

While there has been encouraging progress in the thin film growth part, problems were found in obtaining metallically doped $SrTiO_3$ substrates with the desired electrical/structural properties. A better alternative for the doped $SrTiO_3$ will be the growth of YBCO films on top of a metallic oxide thin film $SrRuO_3$, as will be described in more detail in this report.

2 Progress in realizing the goals

The growth of ultra-thin (<250 Å) films of YBCO using the BaF_2 post annealing process has obtained very good results. Our previous efforts using an oxygen partial pressure of 4 Torr in *ex situ* anneals have demonstrated several advantages of using low oxygen partial pressures in these anneals [1]. We have extended the work by lowering the oxygen partial pressures furtther to 300 mTorr and 40 mTorr to examine

the systematic variation in film properties with the annealing parameters. While the optimum annealing temperature was found to be at 850°C in p_{O_2}=4 Torr, it shifts to 800°C in 300 mTorr and further down to 725°C in 40 mTorr. Among all the oxygen pressures and temperatures, the electrical properties as judged by T_c, J_c, and resistivity optimize at 800°C and 300 mTorr p_{O_2} for 1000Å thick YBCO films. By fixing the annealing duration at 30 min., the optimum annealing temperatures for 500 and 250 Å thick films in p_{O_2}=300 mTorr decrease slightly to be at 775° and 750°C, respectively. These 250Å thick films exhibit a full superconducting transition at ~90K and a room temperature resistivity ~280 $\mu\Omega$-cm. Films produced from the above protocol are used for electron beam writing experiments at Stony Brook [2].

With all the improved electrical properties, surface precipitates become a general feature in the low p_{O_2} annealed films even when stoichiometric film precursors are used. The question has thus been raised whether or not there is an intrinsic change in the composition of the superconducting film matrix to cause to the change in electrical properties. An experiment to answer this question has been carried out using a special set of annealing conditions at 4 Torr p_{O_2} and 700°C. We have varied the Ba/Y ratio in the films to observe a drop in surface precipitates, which are identified as $BaCuO_2$ but have found that at the same time there is an accompanying increase in the abundance of small $Y_2Cu_2O_5$ precipitates dispersed in the film matrix. It was concluded that this behavior is not predictable by using a phase diagram and thus is kinetics related, most probably due to the reduced growth parameters. The matrix superconductor is still stoichiometric with two kinds of precipitates. [3]

The fabrication of metallically doped $SrTiO_3$ has encountered several problems. In our approach, a thin layer of Nb or Ta is deposited on $SrTiO_3$ single crystals, and the Nb/Ta-$SrTiO_3$ is annealed in a vacuum furnace for 4 hours at ~1200°C. The resulting substrates from the anneal are metallic, albeit unacceptable for our work. The reasons

are:

- There is a structural degradation of the substrate, especially at the substrate surface, as detected by ion channeling/Rutherford backscattering (RBS). The formation of a nearly perfect interface with the subsequent YBCO layer will be impossible.
- The geometry of the metallic region in the substrate is not localized and is not even well defined, as measured by RBS.

Either one of the above will significantly deteriorate the performance of the S-N-S junction.

3 Contribution of the work

Compared to the results of optimization of annealing conditions in pure atmospheric oxygen, the use of low oxygen partial pressure shifts the temperature for stable YBCO formation to a lower temperature range, improves the J_c to approach the best values for thin films, and extends the thickness range for growing high quality YBCO films. Films annealed at low oxygen partial pressure, on the other hand, tend to contain greater atomic disorder, as evidenced by the higher channeling yields and slightly lower T_c's in the films annealed from optimum temperatures. Surface precipitates are also observed on stoichiometric films, contrarary to the results of pure oxygen anneals. These changes indicate an increasing resemblance between *in situ* and *ex situ* films when the growth conditions, especially the oxygen partial pressure during growth, are made similar.

Considering the bulk diffusion which dominates in post anneals and surface diffusion in *in situ* film growth, the former growth method requires more driving force than the latter to form films of comparable structural order. This reflects the necessity of using

higher annealing temperatures and/or oxygen partial pressures. The fact has been manifested by our experiment: Although there is a significant decrease in optimum annealing temperature compared to that in p_{O_2}=1 atm by using low oxygen partial pressure, these conditions (750–800°C, p_{O_2}=300 mTorr) are still higher than those used in some *in situ* techniques, such as off-axis sputtering and co-evaporation.

4 Acknowledgement

This research is supported by AFOSR under Grant F49620-92-J-0111.

References

[1] M.P. Siegal, S.Y. Hou, J.M. Phillips, T.H. Tiefel, and J.H. Marshall, "Growth and characterization of $Ba_2YCu_3O_{7-\delta}$ films in reduced oxygen partial pressures using the BaF_2 post-annealing process", *J. Mater. Res.* **7**, 2658 (1992).

[2] M. Gurvitch, S. Tolpygo, B. Nadgorny, S. Shokhor, J.-Y. Lin, F. Tafuri, J.M. Macaulay, A. Bourdillon, S. Hou, and J.M. Phillips, "In-plane high temperature superconducting devices: concept and realization", to appear in Proc. of the 3rd International Conference on Tunneling in low and high-T_c superconductors, (Capri, Italy, 1992).

[3] S.Y. Hou, J.M. Phillips, D.J. Werder, R.M. Fleming, T.H. Tiefel, M.P. Siegal, and J.H. Marshall, "Precipitates in $YBa_2Cu_3O_{7-\delta}$ thin films post annealed at low oxygen partial pressure", submitted to *Appl. Phys. Lett.* (1993).